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ELECTROCHEMISTRY'S DEBT TO EDGAR FAHS SMITH[1]

CATHODE FILM CONTROL IN ELECTROMETAL DEPOSITION

By Professor COLIN G. FINK

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THE outstanding and numerous contributions of Edgar Fahs Smith to chemistry and to learning in general cover a number of distinct fields of endeavor, each one of which would have completely occupied the time of a less gifted scientist than Dr. Smith. His publications alone number at least 200: organic syntheses, electrochemistry, atomic weight determinations, history of chemistry, mineralogy, biography, urinalysis, pedagogics, etc. But, as Professor Bogert pointed out at the memorial service for Dr. Smith seven years ago, the "most important contributions of Dr. Smith were those he made to electrochemistry, a domain in which he was a pioneer and soon became a recognized leader of international reputation. In the hands of this master craftsman, the electric current became a tool of undreamed-of usefulness and possibilities, opening up wholly new methods of analysis, separation and determination. About half of all the research papers he published were based upon new applications of the electric current. His introduction of the rotating anode, together with the employment of currents of high amperage and high voltage, marked a new epoch in the development of electroanalysis. His books on electrochemistry quickly became and have since remained the standard texts in this country, while the Harrison Laboratory was soon known throughout the world for its leadership in this branch of chemistry." Out of 169 papers published in various scientific journals every second one deals with an

[1] Edgar Fahs Smith Memorial Address, slightly curtailed, given on May 23, 1935, at the University of Pennsylvania, Professor Hiram Lukens in the chair.

electrochemical topic. Dr. Smith's first papers on electroanalysis appeared in 1879 in the Proceedings of the American Philosophical Society and in the *American Chemical Journal*. Other papers on the same topic followed at frequent intervals from that time on, but it was not until 1901 that a radical change in Dr. Smith's method of electroanalysis was introduced. In that year while experimenting on the separation of tungsten from molybdenum, Dr. Smith came upon the idea of rotating the anode. He discovered that "by causing the anode to rotate at a high speed, greater current intensity and higher voltage might be applied with an attending, more rapid precipitation of the respective metals."[2]

Then followed the detailed experiments of F. F. Exner, a student working under Dr. Smith's direction. Exner's Ph.D. thesis was published in June, 1903, and the results recorded "were of such remarkable character that many chemists considered the field of electroanalysis to have been truly revolutionized by them."[3]

Although agitation of the electrolyte by some means or other had been suggested by others besides Dr. Smith, it was he who first suggested the combination of a rotating anode and high cathode current densities. Determinations which had previous to 1901, with stationary electrodes and low current densities, taken two to four hours and more, were now, through the findings of Smith and Exner, reduced to 5 to 10 minutes. Furthermore, the quantities that could be accurately determined were more than threefold the quantities by the older methods.

Copper determinations were now made in four minutes; complete precipitation of cadmium in ten minutes; bismuth, lead, silver, zinc, nickel, cobalt, manganese, iron, chromium, uranium, thallium, indium, platinum, palladium, rhodium, molybdenum, gold, tin, antimony, tellurium, arsenic—almost the entire periodic table of elements all precipitated, either as metal or as specific compound, in small fractions of an hour instead of several hours. But this is not all—separations of one metal from another could be carried out more readily and more exactly with the use of the rotating anode—a number of the separations not being even attempted previous to Dr. Smith.

In the summer of 1903 Dr. Smith sent the writer (then pursuing graduate work at the University of Leipzig) a copy of the thesis of F. F. Exner. It was a keen pleasure to repeat a number of the specified tests of Smith and Exner. And it was this work that inspired us to further investigate the basic phenomena involved and started us on our work on chromium, cobalt, tungsten and other metals. Many changes have been made in the apparatus employed by us during these many years. Furthermore, the interpretation of results is quite different to-day from what it was thirty odd years ago. Our thoughts were originally directed to concentration polarization phenomena, whereas to-day we believe that a film of atomic hydrogen and the proper control of the alkalinity of the liquid cathode surface film are of paramount importance.

As regards our apparatus, we directed our attention from the very start to a rotating cathode rather than a rotating anode, as recommended by Dr. Smith. We are operating our cathode to-day at speeds up to 15,000 r.p.m., as against 400 to 1,000 r.p.m. for the anode used by Dr. Smith and his students. With these high-speed cathodes there seems to be almost no upper limit in cathode current density. We frequently use 250 to 500 amperes per square foot, far in excess of the current densities recommended by Dr. Smith.

Before discussing our present conception of the several steps involved in the electrodeposition of a metal, a few of the more interesting experimental results will be recorded. In all these investigations I have been very ably assisted by a host of young students and associates, in particular, Messrs. D. B. Lake, F. A. Rohrman, R. R. Rogers, C. B. F. Young and C. B. de Maya.

Copper Deposition with the High-Speed Cathode

(*a*) *Separation of copper traces from nickel solutions:* A solution of copper-free nickel sulfate was prepared and to this was added one part of copper for every 30,000 parts of nickel. The solution had a pH of 5 and was electrolyzed at 25° C. at a current density of 0.3 amperes per square decimeter. A deposit of pure copper was obtained at a current efficiency of 23.5 per cent. The cathode speed was 3,000 r.p.m.

It is interesting to note that at the low current density recorded above copper alone and no nickel will plate out of solution, when the cathode exceeds a certain speed of rotation. Increasing the current density increases the speed limit. There is a critical polarization value that must be exceeded before any nickel will plate out. Furthermore, even with the high-speed cathode, there is a fairly narrow pH range beyond which no copper will deposit. This point will be more fully discussed below.

(*b*) *Recovery of copper from tails waters:* Tails waters from copper leaching and electrodeposition plants contain appreciable quantities of copper, as much as 0.1 grams per liter. Taking into account the millions of liters that run to waste, the copper that is lost amounts to many hundred tons a year. Due to

[2] Smith's "Electroanalysis," sixth edition, p. 41.
[3] *Ibid.*, p. 41.

the fact that these tails waters contain, besides the copper, a large number of other salts, notably of iron, and this in the ferric state, it is impossible to electrodeposit the copper on a stationary cathode. In fact, we have had cases where the stationary cathode actually went into solution due to the solvent action of the ferric ions. However, upon applying the high-speed cathode, recoveries of copper up to 86 per cent. were obtained at current efficiencies as high as 70 per cent. To cite a definite case, the tails water contained 0.07 g./L. of copper, 0.13 g./L. of iron, besides small quantities of compounds of Si, Al, Ca, Mg, K and Na. The current density was 15 amperes per square decimeter, temperature 30° C., cathode diameter 5 cm and cathode speed 1,500 r.p.m. Current efficiency 68 per cent.; recovery 85 per cent. In other experiments cathode disks three feet in diameter were used. Recovery of copper from tails waters can be accomplished if a satisfactory balance is struck between cost of rotating the cathode and the price of copper. "Raw material" costs are nil.

Ductile Electrolytic Iron

Noteworthy are the results obtained with iron. Using the chloride bath, bright ductile deposits of iron were obtained on the rotating disk cathode at current densities of 15 amperes per square decimeter. With low current densities of the order of 0.3 ampere per square decimeter, no iron deposits when appreciable quantities of ferric ions are present. As the current density is increased, a point is reached where the ferric ions no longer stop the deposition entirely and at higher current densities current efficiencies of 80 per cent. and over are obtainable.

Iron present in nickel sulfate plating baths can be removed by the high-speed cathode. This is so contrary to common older theoretical considerations that it is hard to believe. First of all, nickel is the more noble metal, and, secondly, the concentration of nickel may be over a hundredfold that of iron. But on the basis of our modern conception of the high pH film at the cathode surface, as discussed below, results appear all too plausible.

"Gold from Sea Water"

This is another case in which the high velocity of the cathode plays a most important part. The higher the velocity the better the recovery from gold solutions containing as little as one part per million (or 1 milligram per liter).[4] In a typical experiment a 5 cm diameter nickel disk cathode was used spinning at the rate of 8,500 r.p.m. in three liters of a 3 per cent. salt solution containing 3 mg of gold. The temperature of the solution was 20° C.; pH, 6.00; current density 2 amperes per square decimeter; voltage 8.5. Over 90 per cent. of the gold was plated out at the end of half an hour. It will be appreciated that the gold concentration toward the end of this period was decidedly less than 1 part per million. But hopes of "recovering billions from the five seas" must be dispelled for the present, since the cost of rotating the cathode is about five times the value of the gold recovered. More profitable is this same procedure in the case of the radioactive metals.

[4] Compare with this the arsenic content of the gastric juices of the average normal person, 30 parts per million, or copper in milk 0.6 p.p.m.

Recovery of Polonium

Messrs. Whitaker, Bjorksted and Mitchell,[5] employing our high-speed cathode method, recovered polonium from aqua regia solutions of radium D containing reduced iron and mercury. A silver disk $\frac{7}{8}$ inch in diameter was used and rotated 1,400 r.p.m. Ninety-eight per cent. of the polonium was deposited in about 90 minutes, the solutions containing only 0.0005 curie[6] of radium D in equilibrium with its products. Acid (HCl) concentrations varied between 1/20 *N* and 4 *N* without any noticeable difference in results.

The usual method of obtaining a polonium source from old radium emanation tubes has been described by I. Curie in 1925 and consists of a series of chemical operations and the polonium salts separated from the rest of the solution by a series of precipitations. In the presence of ferric iron and mercuric ions there is no deposition of polonium with stationary electrodes, but with the rotating disk 38 per cent. of the polonium was recovered in spite of the "ic" ions. Upon reducing the ferric and mercuric ions with sulfurous acid, 98 per cent. of the polonium was recovered.

The Effect of Cathode Speed on the Deposition of Alloys

In general we find that in the deposition of binary alloys the composition of the alloy may be easily varied at will by merely changing the speed of the rotating cathode and regulating the current density. Thus, in the case of codepositing cobalt and nickel, the higher the speed the higher the proportion of cobalt in the deposit. Keeping the speed constant at, say, 1,000 r.p.m. and decreasing the current density, the per cent. cobalt in the alloy increases. As a specific example we obtained 27.2 per cent. cobalt in the alloy at a current density of 2 amperes per square decimeter and 43.4 cobalt at 0.22 amperes per square decimeter. The solution was a normal nickel sulfate solution containing one part of cobalt for every 100 parts of nickel. The pH was 5.5, temperature 20° C.

[5] *Phys. Rev.*, 46: 629, 1934.

[6] One curie is equal to 0.59 cubic millimeters of emanation.

Another alloy case is that of zinc-cadmium. Using a solution containing 70 g./L. of zinc, 2½ g./L. of cadmium and 109 g./L. of total sulfate, we found that as the speed of the cathode increased from zero up to 13,000 r.p.m., the per cent. of zinc in the alloy deposit decreased. Furthermore, decreasing the current density decreased the zinc content of the alloy. And increasing the temperature of the solution decreased the zinc content. This all fits in beautifully with our present theoretical interpretation.

What the High-Speed Cathode Accomplishes

It is generally accepted by electrochemists to-day that there exists in intimate contact with the submerged surface of either electrode a film of electrolyte quite different in composition from that of the main body of the bath. Immediately upon electrolysis, the alkalinity of the cathode film increases very appreciably above that of the solution proper and at the same time the alkalinity of the anode film decreases appreciably below that of the bath. This can be illustrated—at least as far as the cathode film is concerned, in which we are primarily interested—by electrolyzing a solution of acid sodium sulfate containing a little phenolphthalein. Upon closing the circuit the solution layer in contact with the platinum cathode turns red, although the main body of the bath is still colorless.

This film at the cathode can be regulated as to its thickness, and as to its pH, by various chemical means, but none of these is as simple and as direct—in particular, for orientation purposes when investigating the electrodeposition of a new metal—as the procedure of changing the speed of the rotating cathode and then its current density. In this way desired results have been obtained in short order, as compared with long, tedious, "hit and miss" methods of the past. And credit for this discovery we unhesitatingly give to Dr. Edgar Fahs Smith. The observations made by him in 1901 to 1903 are at the very foundation of all that followed and led up to a clearer interpretation of the steps in metal deposition.[7]

On the basis of numerous experimental results we find that: (1) A cathode film is essential for successful metal deposition, but that—(2) this film must be held within fairly definite limits as to: (a) thickness and (b) hydrogen-ion concentration. (3) The film can be maintained within these limits most easily by the rotating cathode method, a definite cathode speed and cathode current density corresponding to the desired film thickness and film pH. (4) The film thickness and its pH are different but specific for each metal.

[7] How the thickness and the pH of the cathode film can be varied was shown in six figures projected on the screen.

It has been shown repeatedly that the higher the cathode speed, the thinner the film, without however reaching zero thickness. Furthermore, the higher the cathode speed, the higher the limiting cathode current density for compact, adherent metal plate. And, finally, the higher the cathode current density, the higher the pH of the film.

A number of cases were observed in which no metal plate was obtained with a stationary cathode and yet from the very same solutions, and under otherwise identical conditions, beautiful, reguline metal deposits were produced upon rotating the cathode. In the presence of ferric salts there may be an actual loss in cathode weight when the speed is zero, and a decided gain in weight when the speed is 1,000 r.p.m. or more.

The best film thickness is not the same for all metals. The more noble metals usually require a thinner film than the baser metals. Similarly the pH range for best metallic deposits is characteristic though different for each metal. Thus, zinc and tin have a fairly wide film pH range, nickel, cobalt and manganese a relatively narrow range. If zinc and nickel are present in solution in equimolecular proportion, and the current density increased to a point to bring about a cathode film pH beyond the range for nickel, zinc alone will deposit out, even though nickel is the more noble metal.[8] On the other hand, as recorded above, a trace of copper may be separated from nickel, providing the film pH is held within relatively narrow limits and the cathode speed exceeds a definite value. Copper will plate out at a higher film pH than iron and thus it is possible to recover copper from solutions high in iron when using the high-speed cathode. Iron, on the other hand, will deposit out to the exclusion of nickel, even though this may be in great preponderance, if the cathode film pH is above the nickel limit.

In the case when both cadmium and zinc are present, the more alkaline the film, the less cadmium is deposited. Thus by increasing the current density or decreasing the temperature or decreasing the cathode speed, the less cadmium was found in the alloy deposited on the cathode—and *vice versa*.

Gold will not deposit from sea water with a stationary cathode due to the excessively high pH of the cathode film and its relatively great thickness. Upon rotating the cathode, both film thickness and film pH are very much reduced and bright, solid, pure gold appears on the cathode.

From all available data it is apparent that with the high-speed cathode and/or high current densities applied, the sequence of electrodeposition of metals is not necessarily in the order of their "classic nobility" but may at will be changed about to suit the requirements

[8] Compare Newberry, *Jour. Am. Chem. Soc.*, 51: 1429, 1929.

under consideration. Thus the following order applies within well-defined limits of cathode speed, cathode film pH and current density: zinc, copper, iron, nickel —that is, first zinc, then copper, then iron, then nickel can be plated out.

In conclusion, we strongly recommend the high-speed cathode to all interested in the electrodeposition of those metals and alloys which have to date not been produced from aqueous solutions in solid, adherent, compact and metallic form.

SCIENTIFIC EVENTS

ASCENT OF THE RUSSIAN STRATOSPHERE BALLOON

A SPECIAL cable to *The New York Times,* dated from Moscow on June 26, reports that a surprise flight of a Soviet stratosphere balloon on June 26 reached a height of almost ten miles.

The flight, which was entirely for scientific purposes with no attempt to break altitude records, was reported to have been entirely successful.

The balloon was the U. S. S. R. 1-Bis. It took off from the Kuntzevo military airfield on the outskirts of Moscow at 5:25 and landed at 8 A. M. on a collective farm at the village of Trufanoff, near Tula, 115 miles south of Moscow.

The balloon was the one in which Commander Prokofieff ascended 19,000 meters [62,335 feet] in 1933. Although it had the same gas bag—one of 24,000 cubic meters' capacity, the gondola had been largely reconstructed, strengthened and equipped with the latest scientific equipment.

The balloon contained two Wilson cameras for photographing the path of electrons. These had been built by Professor Alexander Verigo, chief physicist of the Department of Radioactivity and Cosmic Rays at the Geophysical Laboratory in Leningrad, who took observations on the flight. The other equipment included ionization cameras with which he observed the secondary emanations produced by cosmic rays in aluminum and lead, a spectrograph to measure the brightness of the skies and thermographs for measuring outside temperatures.

Besides Professor Verigo those aboard were K. I. Zille, a graduate of the Red Army air academy and one of the most experienced Soviet aeronauts, and J. G. Prilutsky, an engineer, also Red Army trained.

The *Times* states that although there was no announcement of the flight until it had been successfully completed, the balloon and crew had been in readiness to ascend for three days. Clouds and unfavorable winds prevented the take-off until June 26.

From beginning to end of the flight the balloon was in radio communication with the ground. The balloon's radio station was called "Luna" and the earth station "Venus." The radio transmitted word that the balloon was ascending at the rate of five meters (16.4 feet) a second, which slackened to three meters as it reached higher altitudes.

THE HARVARD DREDGING EXPEDITION ALONG THE ATLANTIC COAST

THE dredging expedition undertaken by Harvard University was done on Georges Bank, about 120 miles east of Nantucket Island, Massachusetts, under the direction of Henry C. Stetson, research associate in paleontology, Museum of Comparative Zoology. It will be continued this summer in the Hudson River submarine channel off New York Harbor and in the submarine valleys off the Maryland coast. One of the Maryland coast valleys is the deepest yet found along the Atlantic shore, dropping 9,000 feet below sea level.

Fossils were taken by the expedition from the sides of the Georges Bank valleys, which extend more than a mile below sea level on the edge of the continental shelf. The evidence uncovered is said to confirm the generally supported theory that the deep ocean valleys cutting into the continental shelf were formed by rivers which flowed into the Atlantic before the continental shelf sank below the ocean.

The boat employed by the expedition was the *Atlantis,* of the Woods Hole Oceanographic Institute, an auxiliary steel ketch, 142 feet overall. The dredge used is of the scraper type, of ¾-inch steel plates, with sharp cutting edges.

Eleven successful hauls were made. The middle and upper parts of the valleys between 2,100 and 600 feet were found to be the best areas. Here the walls were either steep enough to prevent the deposition of recent sediment or else the mantle was thin enough to be penetrated. The lower parts of the valleys have gentler grades and the fill of unconsolidated material covers the bed rock so deeply that no rock was found exposed.

In one of these valleys the expedition dredged at a depth of 1,956 to 1,578 feet a coarse sandstone containing fossil mollusks, which Dr. Lloyd W. Stephenson, of the U. S. Geological Survey, has assigned to the Upper Cretaceous period, about 105,000,000 years ago.

From another valley, between 1,968 and 1,740 feet below the sea level, came a greensand, which Dr. Joseph A. Cushman, lecturer on micro-paleontology

at Harvard, has analyzed and has found to contain foraminifera which makes this formation the equivalent of the Buliminia zone of the Navarro of Texas, which is likewise Upper Cretaceous. No material not definitely glacial or recent was found below 1,620 feet.

ELECTION OF OFFICERS OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

AT the meeting at Ithaca of the American Institute of Electrical Engineers, E. B. Meyer, chief engineer of the Public Service Electric and Gas Company of Newark, N. J., was elected president for the coming year. The other officers elected were: *Vice-presidents,* W. H. Harrison, Philadelphia; Mark Eldredge, Memphis; R. H. Fair, Omaha; N. B. Hinson, Los Angeles; C. V. Christie, Montreal; *Directors,* C. R. Jones, New York; W. B. Kouwenhoven, Baltimore; G. C. Shaad, Lawrence; *National Treasurer,* W. I. Slichter, New York (reelected).

These officers together with the following holdover officers will constitute the Board of Directors for the next administrative year, beginning on August 1: J. Allen Johnson (retiring president), Buffalo; J. B. Whitehead, Baltimore; F. O. McMillan, Corvallis; F. J. Meyer, Oklahoma City; G. G. Post, Milwaukee; R. H. Tapscott, New York; W. H. Timbie, Cambridge; F. Malcolm Farmer, New York; N. E. Funk, Philadelphia; H. B. Gear, Chicago; P. B. Juhnke, Chicago; G. A. Kositzky, Cleveland; Everett S. Lee, Schenectady; A. H. Lovell, Ann Arbor; L. W. W. Morrow, New York, and A. C. Stevens, Schenectady.

The annual report of the Board of Directors, presented at the meeting, showed a total membership on April 30 of 14,253. In addition to three national conventions and two district meetings, 1,507 meetings were held during the year by the local organizations of the institute in the principal cities and educational institutions in the United States, Canada and Mexico.

THE RETIREMENT OF PROFESSOR GLENN W. HERRICK, OF CORNELL UNIVERSITY

APPROXIMATELY seventy friends and associates of the department of entomology of Cornell University attended a dinner given in honor of Professor Glenn W. Herrick, of the class of '96, who retired from active teaching in June after more than twenty-five years' service.

Speakers at the dinner included Dr. Liberty Hyde Bailey, emeritus, formerly dean of the College of Agriculture; Professor Simon H. Gage, '77, histology and embryology, emeritus; Dean Cornelius Betten, of the university faculty, and Professor Percival J. Parrott, Grad. '06, vice-director of the State Experiment Station at Geneva. Professor James G. Needham, Ph.D., '98, was toastmaster and read many letters and telegrams from friends unable to be present. Professor Herrick is retiring from teaching to devote more time to research and writing. He spoke briefly of the mixed emotions of the occasion.

Since 1909 he has taught the courses in economic entomology in the College of Agriculture. He returned to Ithaca then as assistant professor, from having been professor of biology and director of the State Experiment Station of Mississippi and later of Texas. In 1912 he was appointed professor of economic entomology and entomologist to the Experiment Station. Recently he has devoted himself especially to the study of insect pests of shade trees, and the University Press is to publish in August his book, "Shade Trees and Their Insect Enemies." He has written many bulletins and numerous other books; among them, "A Text-book of Zoology," "Insects of Economic Importance," "Manual of Injurious Insects," "Insects Injurious to the Household and Annoying to Man," and he collaborated with John H. Comstock, '74, and Anna Botsford Comstock, '79, on their "Manual for the Study of Insects." For several years before it was turned over to the university, Professor Herrick was secretary of the Comstock Publishing Company.

Professor Herrick is a member and former president of the American Association of Economic Entomologists, a member of the American Association for the Advancement of Science, a fellow of the Entomological Society of America, of the Biological Society of Washington, D. C., and of Société Linnéenne de Lyon. He is a member of Quill and Dagger, Sigma Xi and Alpha Gamma Rho.

THE PALISADE INTERSTATE PARK

AT the thirty-fifth anniversary luncheon of the commissioners of the Palisade Interstate Park, the offer of John D. Rockefeller, Jr., of seven hundred woodland acres along the crest of the Palisades from the New Jersey end of the George Washington Bridge to the New York State line was accepted and will be maintained as a park.

According to *The New York Times,* present plans are for the establishment of a continuous park and parkway between the bridge and the state line, a distance of thirteen miles, occupying 1,200 acres of land. Mr. Rockefeller's gift includes about 60 per cent. of this area. The commissioners already hold an additional 16 per cent., leaving 24 per cent., all of it fronting on the Palisades, to be acquired.

South of Palisade Avenue, which runs east and west through Englewood and Englewood Cliffs, the Rockefeller property lies between Hudson Terrace and the edge of the cliffs to a point 2,500 feet below the George Washington Bridge. North of Palisade Avenue it lies

between United States Route 9W and the cliffs. A condition of the offer was that all the property south of Palisade Avenue be held perpetually for park purposes and that all the property north of Palisade Avenue, east of a line 100 feet to the west of the proposed parkway, be maintained in the same manner.

As to the property west of the line, the letter made it conditional that any buildings erected on it should never exceed a certain height, and that it should not be used for commercial purposes "prior to July 1, 1945, if ever."

The restriction on buildings provided that none be erected to a height that "would make it visible from the proposed Henry Hudson Bridge across the Harlem Ship Canal and the proposed parkway extending northerly therefrom along the [Hudson] river, or from an elevation on the easterly side of the Hudson River of seventy feet above mean low-water mark."

This is the second offer made by Mr. Rockefeller. In his first offer he urged an agreement between New York and New Jersey to govern the administration of Palisades Interstate Park. At present the park is administered by separate groups of commissioners from the two states.

Two hundred guests were present at the luncheon, at which messages were received from Governor Herbert H. Lehman, of New York, and Governor Harold G. Hoffman, of New Jersey.

In reference to this gift, but referring to the highlands a little further north, *The Times* writes editorially:

> Anthony Trollope in his "North America" objected to putting to military uses "the prettiest spot on the Hudson"—"one of the prettiest spots which Nature, with all her vagaries, ever formed." He wondered whether the "lads," as he called the West Point students, appreciated that they were studying amid "the sweetest river, rock and mountain scenery that the imagination can conceive." One accepts this tribute of a British visitor to the beauty of this impressive landscape, but is proud that it is a possession of the entire nation. Henry James carried it into the geography of the ideal, to be remembered, as he wrote, not as "the sternest of all seats of discipline," but as "some great Corot composition of young, vague, wandering figures in splendidly classic shades."

BASIC RESEARCH BY THE DEPARTMENT OF AGRICULTURE

ACCORDING to the terms of a bill which has passed both House and Senate in slightly differing forms and which is now in conference, the Secretary of Agriculture "is authorized and directed to conduct research into the laws and principles underlying basic problems of agriculture in its broadest aspects," and also to carry on investigations looking to improvements in handling and marketing, as well as "research relating to the conservation, development of land and water resources for agricultural purposes."

According to a statement by Science Service, the research thus contemplated is to supplement, not to replace, other researches now going on under the aegis of the Department of Agriculture; but both activities are to be coordinated so far as practicable, and "shall be conducted by such agencies of the Department of Agriculture as the Secretary may designate or establish."

The initial funds for this work will amount to $1,000,000. This sum will be increased by an additional $1,000,000 each year until the total reaches $5,000,000, and thereafter the special research fund will be maintained at the latter sum each year. Forty per cent. of the total amount in any one year is to be expended under the direct supervision of the Secretary of Agriculture, in any places and for any research purposes he may approve within the frame of the act. The remaining sixty per cent. will be prorated among state agricultural experiment stations according to the size of their respective rural populations. Funds thus allocated must be matched dollar for dollar by the states receiving them.

The establishment of new laboratories is within the authorizations of the act, since it is provided that funds may be used for the erection of buildings and the purchase or rental of land needed for the purpose. These laboratories might be set up in the major agricultural regions of the United States, in places designated by the Secretary of Agriculture.

SCIENTIFIC NOTES AND NEWS

DR. RICHARD CHACE TOLMAN, professor of mathematical physics at the California Institute of Technology, was elected at the Los Angeles meeting president of the Pacific Division of the American Association for the Advancement of Science. He succeeds Dr. Bailey Willis, emeritus professor of geology at Stanford University.

AT the semi-annual meeting at Cincinnati of the American Society of Mechanical Engineers the Holley Medal for 1934 was awarded on June 20 to Dr. Irving Langmuir, associate director of the General Electric Research Laboratory, for his "contributions to science and engineering, especially in the development of the gas-filled incandescent lamp, of the thoriated filament for thermionic emission, of atomic-hydrogen welding, of phase-control operation of the Thyratron tube, and

in fundamental research in oil films." Dr. Langmuir presented a paper at the meeting, entitled "The Mechanical Properties of Matter."

THE Lamme Medal of the American Society of Engineering Education was presented to Dr. William Elgin Wickenden, president of the Case School of Applied Science, at the recent Atlanta meeting. The medal is awarded each year "for accomplishment in technical teaching or actual advancement of the art of technical training."

DR. JONAS S. FRIEDENWALD, associate professor of ophthalmology at the Johns Hopkins University, in charge of research laboratories at the Wilmer Institute, was awarded the gold medal of the American Medical Association for distinguished work in ophthalmology, at the recent convention at Atlantic City.

MEDALS of special recognition were conferred by the American Radium Society at its annual meeting in Atlantic City on Dr. James Ewing, professor of oncology at the Cornell Medical College, on Dr. Francis Carter Wood, director of the Institute of Cancer Research of Columbia University, and on Dr. George E. Pfahler, of Philadelphia, who have respectively given the annual Janeway lectures at the last three annual meetings of the society.

AT a court dinner of the Society of Apothecaries of London, held in the hall of the society on June 4, Sir Frederick Grant Banting, professor of medical research in the University of Toronto, was presented with the society's gold medal "for valuable services rendered to the science of therapeutics." Previous recipients of the medal have included Professor W. E. Dixon, Sir F. Gowland Hopkins, Professor J. J. Abel, Professor Fourneau and Sir Henry Dale.

THE first award of the Hickman Medal of the British Royal Society of Medicine has been made to Dr. Wesley Bourne, of the department of pharmacology of McGill University. The Hickman Medal was founded in 1931 and its award is made for "original work of outstanding merit in anesthesia or in subjects directly connected therewith." The medal will be awarded at intervals of not less than three years.

DR. S. LEFSCHETZ, professor of mathematics at Princeton University and president of the American Mathematical Society, has been elected a member of the Royal Society of Letters and Sciences of Bohemia.

DR. WILLIAM MANSFIELD CLARK, De Lamar professor of physiological chemistry at the Johns Hopkins University, received the honorary degree of doctor of science at the commencement exercises of Williams College.

BROWN UNIVERSITY conferred at commencement the doctorate of science on Dr. Ernest E. Tyzzer, professor of pathology in the Harvard Medical School.

DR. ALFRED C. REED, director of the Pacific Institute of Tropical Medicine of the University of California, received the degree of doctor of science at the commencement exercises at Pomona College, where he gave an address entitled "Environmental Medicine." Dr. Reed graduated from the college in 1906.

THE honorary degree of doctor of science has been conferred by Purdue University on Dr. Grover Francis Powers, professor of pediatrics at the Yale University School of Medicine.

LAWRENCE COLLEGE, Appleton, Wis., has conferred the honorary degree of doctor of science on Dr. Alfred N. Goldsmith, vice-president and chief broadcast engineer for the Radio Corporation of America, "in recognition of the unique place which he had made in his chosen field." Dr. Goldsmith is past president of the Institute of Radio Engineers and of the Society of Motion Picture Engineers.

DR. L. R. JONES, for twenty-six years professor of plant pathology at the University of Wisconsin, and Professor Ransom A. Moore, head of the department of agronomy, which he joined as instructor in 1895, have retired from active service with the title emeritus.

ACCORDING to an Associated Press dispatch, Dr. Raymond A. Pearson was asked on June 28 by the board of regents of the University of Maryland to place in their hands his resignation as president of the university on July 1. This action was taken after consideration of criticism of Dr. Pearson's administration. Dr. Pearson, it is reported, was informed that if the resignation were tendered as requested he would be asked to remain at the university for a time as consultant in its land-grant activities. Dr. Pearson was formerly professor of dairy industry at Cornell University; from 1908 to 1912, he was New York State Commissioner of Agriculture and from 1912 to 1926 he was president of Iowa State College.

DR. WILLIAM R. GALBREATH, clinical professor of tropical medicine at Columbia University, has resigned.

DR. JOHN A. SCHAEFFER, vice-president and director of research of the Eagle-Picher Lead Company at Joplin, Mo., has been elected president of Franklin and Marshall College at Lancaster, Pa. Dr. Schaeffer is a son of the late Nathan C. Schaeffer, first superintendent of public instruction of the State of Pennsylvania.

DR. ALBERT C. BRODERS, of the Mayo Clinic at Rochester, Minn., has been appointed professor of

surgical pathology and director of cancer research at the Medical College of Virginia, Richmond.

DR. C. H. RAGLAND, who since 1928 has been connected with the division of pomology of the University of California, has resigned to become head of the department of horticulture at Mississippi State College.

DR. JOHN A. WHEELER has been appointed assistant professor of physics in the University of North Carolina at Chapel Hill. During the past year he has carried on work in nuclear physics at the Institute of Theoretical Physics in Copenhagen.

PROFESSOR A. NORMAN SHAW has been made head of the department of physics and director of the Macdonald Physics Laboratory at McGill University, in succession to Professor A. S. Eve, who retired at the close of the academic year.

DR. FRANCIS DAVIES, reader in anatomy in the University of London, will succeed Professor C. J. Patten, Jackson professor of anatomy in the University of Sheffield, who is retiring.

THE Board of Scientific Directors of the Rockefeller Institute for Medical Research announces the election of Dr. Alphonse Raymond Dochez as a member of the Board of Scientific Directors. The following promotions and appointments are announced: *Promotions:* Assistant to associate, Dr. Joseph W. Beard, Dr. Harry S. N. Greene, Dr. Kenneth C. Smithburn and Dr. Wendell M. Stanley. Fellow to assistant, Jonathan Biscoe, Joseph S. Fruton, Dr. George L. Graham, Dr. George I. Lavin, Dr. Charles V. Seastone, Jr., Dr. William Trager and Dr. Arnold J. Ullstrup. *New appointments:* Assistants, Dr. L. Edgar Hummel and Dr. Robert J. Parsons. Fellows, Dr. William Halsey Barker and Rollin D. Hotchkiss.

DR. BOWMAN C. CROWELL, director of clinical research at the American College of Surgeons, Chicago, has been elected president of the Gorgas Memorial Institute. He succeeds Rear Admiral Cary T. Grayson, who recently took over command of the American Red Cross. Admiral Grayson has been chosen chairman of the board to succeed the late Dr. Franklin Martin, founder of the institute, who died in Phoenix, Ariz., on March 7. The new surgeon-general of the army, Major General Charles R. Reynolds, was chosen a member of the board to succeed Major General Robert U. Patterson. Dr. Maurice C. Hall, director of the Bureau of Animal Industry of the Department of Agriculture, was elected a member of the Scientific Board.

DR. STANLEY A. CAIN, Waterman research fellow at Indiana University, has been placed in charge of the School of Plant Sociology, which has been developing at the Long Island Biological Laboratory at Cold Spring Harbor, Long Island, under the direction of Professor Henry S. Conard, of Grinnell College, Iowa.

DR. JOHN L. ULRICH, of the department of zoology of the Johns Hopkins University, has received a grant from the American Medical Association for the study of cerebral functions in the action of antagonistic muscles.

THE following delegates will officially represent the Botanical Society of America at the sixth International Botanical Congress, to be held in Amsterdam from September 2 to 7: Aven Nelson, president of the Botanical Society of America; Karl Sax, B. M. Duggar, B. O. Dodge and A. S. Hitchcock. Alternates are Donald Reddick and H. A. Gleason.

THE John R. Freeman Scholarship, offered annually by the American Society of Mechanical Engineers, has been awarded to Victor L. Streeter, of Denver, who has been a junior engineer with the U. S. Reclamation Bureau. The award grants the sum of $1,500 for fifteen months' travel and research in Europe.

DR. WALTER B. CANNON, of Harvard University, was guest speaker at the annual meeting of the Sigma Xi Club of Peking held on May 17. The officers elected for the following year were: *President,* Y. C. Mei, of Tsinghua University; *Vice-president,* S. D. Wilson, of Yenching University; *Secretary-Treasurer,* K. P. Young, National Academy of Peiping.

OFFICERS of the Society for the Promotion of Engineering Education for 1935–36 were elected at the Atlanta meeting as follows: *President,* Dean D. S. Anderson, Tulane University; *Vice-presidents,* Dean P. H. Daggett, Rutgers University, and Dean S. B. Earle, Clemson Agricultural College; *Secretary,* Professor F. L. Bishop, University of Pittsburgh; *Treasurer,* W. O. Wiley, John Wiley and Sons; *Members of Council,* Professor Theodore H. Morgan, Worcester Polytechnic Institute; M. M. Boring, General Electric Company; Dean J. W. Barker, Columbia University; Professor S. C. Ogburn, Bucknell University; Professor F. L. Plummer, Case School of Applied Science; Professor L. E. Grinter, Texas Agricultural and Mechanical College, and Professor A. B. Domonoska, Stanford University.

THE Italian-American Chemical Society was organized at a meeting held at New York University on June 19. Its objects are to facilitate the exchange of scientific and technical information between America and Italy, and at the same time to bring into closer friendly and personal contact the chemists and industrialists of both countries. The establishment of the society followed the favorable expression of S. E.

Professor Nicola Parravana, of Rome, president of the Associazione Italiana di Chimica, to a request sent him through S. E. Professor Filippo Bottazzi, of Naples, by a meeting held at Casa Italiana, Columbia University, on January 26. The initial officers are: *President,* Jerome Alexander; *Vice-president,* William C. Mac Tavish; *Secretary and Treasurer,* Genio F. Reale; *Council,* Kenneth C. Blanchard, Frank Brescha, G. de Bethune, Alexander O. Gettler, Joseph Matiello, Vittorio Molinari Ernest Conti, Wallace T. Cohoe, Harold C. Urey and F. Quattrone.

THE Latin-American Congress of Physical Therapy, X-ray and Radium will hold its first annual congress in Mexico City, from August 29 to September 5, according to an announcement made by Dr. Cassius Lopez de Victoria, executive director of the society and director of the National University of Mexico. The gathering will include physicians and workers in the field of medicine, surgery and allied subjects. Five tours to the congress have been arranged by the American Express Travel Service, with a home-bound opportunity of attending the conference on physical therapy at Kansas City, to be held from September 9 to 12. On the ocean route the delegates will leave New York on August 22, on the steamship *Yucatan.* After visiting Havana, Mexico will be entered through Vera Cruz. Sightseeing excursions will cover Mexico City and its environs. Delegates going by rail will leave New York on August 27. They will cross the boundary at Nuevo Laredo, arriving at the capital on August 31. The two tours have been planned to allow stopovers at Kansas City with a combination privilege of the water route to Mexico and return by rail.

A GROUP of seventy German physicians sailed from Hamburg on June 26 to make a study of hospitals in the United States. The trip was organized by the German Association for Medical Study. They will be the guests of the American Medical Association and the American Academy of Medicine. After leaving New York, a visit is planned to the hospitals of Buffalo, Detroit, Chicago, Philadelphia and Washington.

THE London *Times* publishes the following wireless message from Dr. Noel Humphreys, leader of the Oxford University Expedition which is exploring Ellesmere Land, and especially Grant Land, after wintering at Etah in North Greenland: "Thule (N. Greenland), June 7.—All well. All members of the expedition have returned to Etah. Each party got into unexplored country and discovered new mountains. The short crossing of Ellesmere Land has been completed and valuable geological work done. Unexplored Grant Land has been penetrated and a new range estimated at 10,000 feet found north of United States Mountains. The expedition is making scientific collections locally until the ship arrives."

A REUTER'S dispatch, printed in *The New York Times,* reads: "A complete issue of the works of Sir Isaac Newton and a new international botanical dictionary compiled in eight languages are to be published in Soviet Russia. The botanical dictionary will be in Latin, English, French, German, Russian, Italian, Dutch and Armenian. It is being compiled by Professor A. L. Bedelyan, of the Armenian Agricultural Institute. When complete it will contain an alphabetical list of the names of every known plant. Printing of the Newton edition will be carried out by the History of Science and Technique of the Academy of Science of the U.S.S.R. in conjunction with the Scientific-Theoretical Publishing House."

THE Lassen Volcano Observatory, which was established by the U. S. Geological Survey in 1926 for the study of volcanic processes and recent volcanism in northwestern United States, was discontinued on June 30 as an economy measure.

ACCORDING to the United Press customs officials at Tientsin have forbidden the exportation of the archeological collections made by Sven Hedin, pending government advices. The Committee for Preservation of Ancient Articles has appealed to the government not to permit this collection to go abroad.

DISCUSSION

THE PROTECTION OF BIRDS MADE PROFITABLE

MANY scientists and agriculturists, familiar with the commercial importance and historic interest of Peruvian guano, may not realize that the production of guano is a continuing process of considerable economic significance. The production is many times greater now than it was in 1908, but even then, when the population of birds on the Peruvian Islands was at its lowest ebb, it was conservatively estimated that the current production was 20,000 metric tons or more of very high-grade guano (12 to 17 per cent. nitrogen), and that the annual requirement of national agriculture was about 40,000 tons.[1] The contrast of these two figures pointed to a serious national problem, since the old deposits of "mineral" guano were ex-

[1] R. E. Coker, *Proceedings of the U. S. National Museum,* 56: 449–511, Pls. 53–69, 1919.

hausted, except for scattered deposits of material of very low grade. The national problem was only aggravated by the fact that there were already mortgaged to the Peruvian Corporation Ltd. of London hundreds of thousands of tons which only the future could provide and which assuredly it could not provide without a radical change of policy by the government and the commercial interests concerned.

Fortunately, there was a change, the cardinal features of the new policy[2] being the unification of responsibility for extraction of guano and protection of the birds and the rotation of working and protected areas in periods of years. Under the new plan, which superseded the old arrangement of having closed seasons of months, the birds would enjoy homes that were entirely undisturbed during *all the year* and for *as many years in succession* as was consistent with the utilization of the deposits of guano.

There has recently appeared a very comprehensive and detailed quarticentennial report of the guano administration entitled "25ª Memoria del Directorio de la Compañia Administradora del Guano, correspondiente al 25º año económico de lº de Abril de 1933 a 31 de Marzo de 1934."[3] The most significant facts presented in this report are, first, that the extraction of *guano rico,* which is now *new* guano, had risen in the fiscal year 1933–1934 to the significant amount of 157,634 toneladas; and second, that, of this amount, 115,402 toneladas were used in national agriculture. The figures quoted do not include *guano pobre,* insignificant in amount and value. In short, for the last year of report the farmers of Peru had obtained nearly three times as much rich guano as was needed, but not obtainable in 1908, while nearly 50,000 tons were still available for export.

The extraction from year to year must vary considerably, not so much because of fluctuations in avian population as because of the policy of rotation of areas of operation with corresponding rotation of areas of absolute non-molestation of the birds; but if the total period covered by the report be divided into five periods of five years each and the average annual yield for the successive five-year periods be arranged in chronological order, the following instructive series is obtained:

1909–1914	50,916	toneladas (metric tons)
1914–1919	63,866	"
1919–1924	75,280	toneladas (metric tons)
1924–1929	113,749	"
1929–1934	121,131	"

Even from such a rough statistical analysis, it is apparent that the good results of the protective measures have been generally progressive up to the present time (with over 157,000 toneladas in the last year).[4] It is also indicated that the results of the protective measures may not yet have come to full fruition. It takes time for nature to restore a balance that man has blunderingly upset. Perhaps this story has a general biological interest.

Another story, more directly in the line of natural history, is pertinent to the one just told, but the facts of the second story must not be assumed to explain in great measure the practical results that have been cited. That careful student of natural history, Dr. J. J. von Tschudi, who spent four years in Peru *just before* the modern commercial extraction of guano began, said[5] that the variegated gannet, *Sula variegata* Tschudi, was the chief guano-producing bird, that it nested only on the barren islands and not on the mainland and that it made nests in the sand, implying that it had extensive rookeries on the level parts of the islands. Not one of these statements was applicable in 1907 and 1908. The gannets of this species nested almost exclusively on the faces of steep cliffs, its nesting areas only rarely overflowing to a very slight extent onto ground on which a man could find a fair foothold. The geographer, Raimondi, in 1856,[6] *a few years after* guano extraction had begun, confirmed Tschudi by stating that the Sulas "keep themselves in the interior of the islands" (translation). Some years later[7] he uses a more qualified expression—they cover *at times* a part of the islands ("cubren a veces la parte de las islas"). Could von Tschudi and Raimondi have been mistaken, or had this bird changed its nesting habit with the development of the guano industry during the latter half of the nineteenth century?

Now it happened that *about ten years after the new plan* of conservation had come into effect, Dr. Murphy visited some of the same islands on which my observations were made and took photographs showing

[2] R. E. Coker, SCIENCE, n. s., 28: 56–64, 1908. At a later time a further report was made to the Peruvian Government by H. O. Forbes. Although this report seems not to have been published, it is understood to have been in general conformity with the original plan but more detailed and of very great practical value to the government.

[3] *Boletin de la Compañia Administradora de Guano,* Vol. 10, No. 7, Lima, Peru, 1934.

[4] See also: Robert Cushman Murphy, *Brooklyn Museum Quarterly,* October, 1920; R. E. Coker, SCIENCE, n. s., 53: 293–298, 1921.

[5] J. J. von Tschudi, "Travels in Peru during the Years 1838–1842." Translation by Thomasina Ross, pp. xi + 354, New York, 1852 (p. 168); "Untersuchungen über die Fauna Peruana," Vol. 2 (First Part), "Ornithologie," 316 pp., 36 Pls. St. Gallen, 1844–46 (p. 313).

[6] Antonio Raimondi, "Le huano des isles de Chincha," 1856.

[7] Antonio Raimondi, "El Perú." Estudios Geológicos, Parte Quarta, Trabajos Sueltos. La Sociedad Geográfica de Lima, 1902 (p. 494). The section about guano and the birds was apparently written about 1860 or earlier.

great rookeries of this species on the level or gently sloping ground—just the condition that von Tschudi and Raimondi had encountered on the islands. Such a photograph as Murphy shows opposite page 304[8] could not possibly have been taken in 1908. The statement is not lightly made. I saw hundreds of rookeries of this species on islands and mainland over some 700 miles of the coastal region during a period of a year and a half and made many inquiries with the particular aim of checking the statements of von Tschudi and Raimondi. The conclusion seems inescapable that *Sula variegata* did originally nest extensively on level ground (and doubtless also on the cliffs), that some time during the period of unregulated extraction of guano, it gave up practically entirely the level areas, and, seemingly, found previously unfrequented cliffs on the mainland, and that it subsequently reclaimed the level areas when conditions made it feasible to do so. It is still believed, however, that von Tschudi was incorrect in ascribing chief importance to the gannet, locally known as "piquero" or "camanay." The fact that the name "guanay" or "huanay" was applied by the indigenous Peruvians to the white-breasted cormorant, taken together with the knowledge of its habits and the ascertained facts regarding the amount and quality of the guano it produces, points to the primacy of this species as a producer of the fertilizer that was valued by the Incas, and doubtless by their predecessors.

R. E. COKER

UNIVERSITY OF NORTH CAROLINA

AN ABSTRACTING SERVICE FOR TECHNIQUE IN BIOLOGICAL MICROSCOPY

THE journal *Stain Technology,* the official publication of the Commission on Standardization of Biological Stains, is now in its tenth year and plans are being made for enlarging its scope with the beginning of 1936.

This journal has, almost since the beginning, consisted of two parts—one composed of original articles; the other of reviews of articles dealing with microtechnique that have appeared in other journals. The original articles at first dealt wholly with stains and staining procedures, but as it became known a few years ago that the editors were willing to receive more general contributions along other lines of microtechnique, their scope has gradually been widening and for about three years the journal has carried on its cover page as a sub-title the name "A Journal for Microtechnique." Recent numbers, in fact, have included an unusually large number of papers dealing with other subjects beside stains and staining.

The abstract section of the journal, which has been entitled "Laboratory Hints from the Literature," has always included microscopic methods in general, although the greater number of the articles reviewed have had to do with staining procedures, methods of fixation, etc. The abstracts have always been of distinctly unusual style in that the plan has constantly been followed of giving enough of the author's technique in the abstract so that it could be followed without consulting the original article. Up to the present time, however, the articles reviewed have been only those appearing in a limited number of journals available at Geneva, N. Y., where the commission laboratory is located. For this reason, the field has never been covered as completely as might be desired.

Beginning with January, 1936, however, it is hoped to cover in this abstracting service a much larger list of journals. A list of nearly 100 periodicals has been drawn up in which articles on microtechnique often occur and it is desired to cover in the future as many as possible of the journals on this list. It is obvious that not all this can be done in the future at the Commission offices as it has been in the past. Assistance must be obtained from biologists elsewhere in reporting on the methods published in many of these journals. The editors have already secured about 15 collaborators who have promised to assist in the necessary abstracting work, but additional abstracters would be desirable. If any of the readers of this article, therefore, are sufficiently interested in this undertaking to be willing to abstract a few articles each quarter, it will be appreciated very much if they would get in touch with the writer of this note and indicate their willingness.

The object in this proposed development is to convert *Stain Technology* into a journal which presents in a clear, concise and usable form not only the latest news concerning the biological uses of dyes, but also the most recent methods in general biological microscopy. No other periodical does this at the present time, the usual abstracting journal in the biological field laying its stress on results rather than on methods. It is hoped that the proposed plan will make *Stain Technology* a more useful factor in the field of microtechnique than it has been in the past.

H. J. CONN

GENEVA, N. Y.

THE ANTIVIVISECTION FIGHT IN ILLINOIS

THE methods employed by the Illinois Society for the Protection of Medical Research in combatting antivivisection activities in Chicago during the winter of 1934–35 may be of some interest to biologists in

[8] Robert Cushman Murphy, "Bird Islands of Peru," pp. xx + 362. New York and London, 1925, Putnam's. Illustrated with photographs taken in 1919 or 1920.

ther communities where similar activities may be instituted. Acting on the assumption that a part of the upport accorded the antivivisectionists by the lay ublic is based on misinformation, an extensive public ducation program was undertaken.

This campaign was carried on by means of public ddresses, debates, radio talks, distribution of literature and personal letters. Over one hundred addresses ere made before women's clubs, business men's organizations, Parent-Teacher groups, church groups, igh school and junior college groups, college alumni rganizations and open meetings. A number of public debates were held in which both sides were represented. Through cooperation with various medical nd other professional organizations, more than thirty adio programs were presented. Some of these were rief, concise discussions of the results of animal experimentation and the significance thereof to society; thers were presented as a forum or dialogue. Practically every radio station in Chicago gave free time.

Reprints of published articles, specially prepared mimeographed discussions and other literature were widely distributed. At a conservative estimate more than 100,000 pages of such material were distributed. Contrary to the conventional views about such procedures, the response was such as to indicate that the general public did display an intelligent understanding of the problem. With the exception of one of the Hearst publications the newspapers in general gave sympathetic support to the society's efforts.

While many physicians and lay people, both men and women, participated in the campaign and rendered valuable assistance, the brunt of the work fell upon the active members of the society, and of these the most active and most effective were Drs. Luckhardt, Carlson, Ivy, Visscher, Boyd and Thalhimer, who made up the nucleus of the very widely extended organization which finally accomplished the defeat, locally, of this pernicious attack on scientific research.

C. I. REED

UNIVERSITY OF ILLINOIS COLLEGE OF MEDICINE, CHICAGO

SCIENTIFIC BOOKS

ELECTRONS

Electrons (+ and −), Protons, Photons, Neutrons, and Cosmic Rays. By R. A. MILLIKAN. The University of Chicago Press. 492 pp. Price $3.50.

THIS new book may be regarded as a third edition of "The Electron," which appeared in 1917, but six new chapters have been added on "Waves and Particles," "The Discovery and Origin of the Cosmic Rays," "The Spinning Electron," "The Positron," "The Neutron and the Transmutation of the Elements" and on "The Nature of the Cosmic Rays." The new chapters contain many excellent illustrations.

Like the first edition the third is largely devoted to the researches of the author and his coworkers. It contains besides enough about the work of other physicists to enable the reader to appreciate the bearing of the author's work on theirs.

This book is admirable and most interesting. It is well written and not too technical. It should enable a reader with very little scientific knowledge to get some real insight into the recent rapid advance in physical science to which the author and his associates have contributed so much. The author describes his own experiments and the wonderful technique with which he overcomes extraordinary difficulties and obtains exact results where previous investigators have been content with little better than qualitative indications. It is a record of a splendid series of researches all so well done that the results are likely to stand unchallenged for many years. No better book could be given to an undergraduate thinking of taking up physics seriously. The intensely interesting and surprising character of the recent experimental and theoretical advances discussed should appeal to the imagination and ambition. Above all the author makes it clear that physics is a living subject advancing with ever-increasing speed and that it will surely reward the seeker after truth as richly as he deserves. No one can doubt that the next twenty years will bring forth new facts and theories which will change civilization as much or more than Faraday's researches in the nineteenth century.

H. A. W.

WILD FLOWERS

Wild Flowers. By HOMER D. HOUSE. 362 pp. 299 illustrations; 264 colored, 35 half-tone. The Macmillan Company. Price $7.50.

ONE of the most needed types of flora is one with accurate photographic illustrations from which plants may be identified so far as to superficial characters. While this has been done before in certain groups of plants, House's "Wild Flowers" makes a step in this direction for the floristics of a large area. While a great deal of the book, especially the illustrations, is a reissue of a New York State Museum publication, in its present state it is more convenient for use and available to a greater public. The size and clarity of the illustrations make identification much easier for such plants as are included, and make one wish that more than 400 out of the many thousand plants that

grow within the area the book is said to cover had been so illustrated. That of course would make too expensive and bulky a book; in fact, it would have to run to several volumes, so one must be contented with the quantity illustrated in the present work.

Mr. House's simple clarity of description and interesting form of writing must be taken as compensation for the faulty reproductions of color in the illustrations, where the greens are especially bad, the yellows frequently too orange and the pinks and purples too weak or dull. This is possibly due in part to the imperfections of color photography, which, while satisfactory enough in many ways, still has the unsatisfactory tendency to reduce colors to monotones, not having reached the state of perfection where all tones and shades of color can be reproduced.

The rather rash promise made on the inside of the jacket that any wild flower may be quickly and easily identified by the use of this book is regrettable. Whether this statement is intended to apply to any wild flower in the United States is doubtful, but since the plants included are nearly all northeastern except for the wide-spread introduced weeds, the book is clearly applicable to that region, in which between 4,500 and 5,000 species and varieties of plants are known. Grasses, sedges, rushes and trees are omitted, probably for the popular reason of not thinking of them as wild flowers, an acceptable enough reason in a book intended for popular use, since these groups are too difficult for the average person to identify. The book, however, is such an excellent pioneer in its type of field that it becomes a fine book of reference fo flower-lovers.

E. J. ALEXANDER
NEW YORK BOTANICAL GARDEN

THE DIATOMACEAE

An Index to the Genera and Species of the Diatomaceae and Their Synonyms, 1816–1932. By FREDERICK W. MILLS. Pts. 1–21. Wheldon and Wesley, London, 1933–1935, 1726 pp., 1 portrait.

INDEXES and bibliographies constitute some of th most valuable tools of the research worker, yet the preparation seems always to lag far behind. Som of the difficulties seem to be associated with the mean of publication. A few librarians recognize the use fulness of such works for reference purposes, an specialists in particular groups acquire them, but i general they are overlooked to such an extent tha publishers can not afford to risk the financial loss con nected with the printing.

In the present case Mr. Mills has devoted a lon life to the preparation of this index. Naturally it i not perfect; no index ever is, but he did manage t assemble some half a million important references t the literature. In order to make publication possibl at all it was printed by the "multitype" (mimeo graph) process and this may prove to be the solutio of the problem facing many authors of referenc works, only small editions of which are needed.

G. D. HANNA
CALIFORNIA ACADEMY OF SCIENCE
SAN FRANCISCO

SCIENTIFIC APPARATUS AND LABORATORY METHODS

A MODIFIED MEDIUM FOR THE STUDY OF INTESTINAL LACTOBACILLI

FOR the cultivation of the Lactobacillus group of organisms many different kinds of special media are available, the selection depending entirely upon the purposes in view and the types of Lactobacilli studied. In this laboratory the Bacto-Peptone tomato agar, a modification of Kulp and White's medium,[1] has been employed for several years as a plating medium in the isolation and study of intestinal lactobacilli. In this medium, under properly established gaseous environment, the characteristic filamentous colonies (fuzzy X type) of *L. acidophilus* are usually obtained. The colonies remain quite small, however, and are difficult to differentiate from other microscopic colonies present.

Recently we have used Neo-Peptone (Difco) in preparing the tomato agar and have found it to offer considerable advantage in the plating of *L. acidophil* of intestinal origin. In comparative quantitative e periments the following differences were obtained i favor of Neo-Peptone tomato agar, as compared t those obtained on the same medium prepared wit Bacto-Peptone.

The results presented in Table I were obtained wit pure culture strains of *L. acidophilus* in milk. Th increases in plate counts varied from 12.3 to 166.0 pe cent. In a general way the stimulation was mo noticeable with the strains which showed the lowe plate counts in Bacto-Peptone tomato agar.

Additional evidence (not presented in the table was obtained in quantitative platings of rat fece From 10 to 30 per cent. higher *L. acidophilus* count were invariably the rule in Neo-Peptone tomato agar The medium was especially advantageous for deter mining the *L. acidophilus* ratio to other bacteria i feces of white rats kept on various diets. Due to thei increased size and enhanced filamentous characteristi

[1] SCIENCE, 76: 17, 1932.

TABLE I

SHOWING COMPARATIVE PLATE COUNTS OF L. ACIDOPHILUS ON NEO-PEPTONE TOMATO AGAR AND BACTO-PEPTONE TOMATO AGAR

Colonies per cubic centimeter of culture plated in:		
Neo-Peptone tomato agar	Bacto-Peptone tomato agar	Percentage increase in Neo-Peptone
627 M	559 M	12.30
670 "	592 "	13.00
854 "	746 "	14.40
900 "	774 "	16.00
601 "	518 "	16.00
673 "	577 "	16.66
145 "	123 "	17.80
459 "	376 "	22.00
885 "	713 "	24.10
1,028 "	826 "	24.40
538 "	431 "	24.80
548 "	419 "	31.00
563 "	427 "	31.80
714 "	537 "	32.90
366 "	270 "	35.00
621 "	451 "	37.60
439 "	309 "	42.00
247 "	171 "	44.00
374 "	235 "	59.00
399 "	249 "	60.20
190 "	113 "	69.10
276 "	149 "	84.90
17 "	7 "	166.00

M = millions.

the colonies of *L. acidophilus* were recognized easily under hand lens magnification.

Quantitative studies were not conducted with other types of lactobacilli. However, in comparative qualitative trials it was found that strains of *L. pentoaceticus, L. delbrücki, L. fermentatae* and *L. odontolyticus* all developed larger colonies in Neo-Peptone tomato agar than in Bacto-Peptone tomato agar. Aside from this the colony characteristics remained unchanged.

The composition and the preparation of the medium is as follows:

Tomato juice	400 cc
Peptonized milk (Difco)	10 gm
Neo-Peptone (Difco)	5 gm
Water	600 cc
Agar	11 gm

The tomato juice is obtained by filtering the contents of one No. 3 can of tomatoes through filter paper. The peptone and peptonized milk are added to the tomato juice and heated gently until dissolved. The reaction is adjusted to pH 6.8. The agar is added to 600 cc of water and melted in the autoclave. The melted agar and the tomato juice-peptone-peptonized milk solution are mixed while hot and the medium tubed. Sterilization is made by autoclaving at 120° C. for 8 minutes. The medium should be removed from the autoclave as soon as possible.

The plates inoculated with material containing *L. acidophilus* and poured with Neo-Peptone tomato agar are incubated for 48 hours at 37° C. in an atmosphere containing approximately 10 per cent. carbon dioxide.

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THE CULTURING OF FRESH-WATER AMOEBAE IN THE LABORATORY

IN growing amoebae for experimental purposes in Dr. Chambers's laboratory at New York University, we have hit upon a simple method which ensures a plentiful and continuous supply.

The method consists in having a layer of agar with starch grains in the bottom of the culturing bowls. The agar serves not only to anchor the starch grains, but also offers a good surface for the amoebae to feed and crawl upon. The agar is prepared by dissolving 1½ grams in 100 cc hot water; and pouring the solution, while hot, through a filter of absorbent cotton into a thoroughly cleaned and dried finger bowl. The amount should be in sufficient quantity to form a thin layer of about 0.2 cm thick on the bottom of the bowl. Several grains of ordinary polished white rice are dropped on the layer before the agar has set.

When the agar has hardened, 10 to 15 cc of culture water, containing as large a number of amoebae as possible, is poured into the bowl and an equal quantity of distilled water then added. Each day 5 cc of distilled water is added until the bowl contains about 50 cc of liquid. In adding the water, the contents of the bowl should be agitated as little as possible, so as not to disturb the amoebae, which tend to gather about the starch grains.

The bowls should be covered to minimize evaporation, and should be kept at a temperature (17 to 18° C.) somewhat below usual room temperature. To maintain a constant temperature, the bowls may be stored in any kind of a water bath, with water from the tap constantly circulating around it.

Cultures prepared in the way described above will, within two to four weeks, develop thousands of amoebae per bowl, and they will often last for several months without subculturing.

The presence of large numbers of Chilomonas is very favorable for the cultures, as they serve as food for the amoebae. Fresh grains of rice should be added

from time to time. No harm results if the grains loosen from the agar and crumble as the culture ages. The agar frequently loosens from the bottom of the dishes, whereupon the amoebae will be found in large numbers on the agar film and on the glass bottom of the vessel. It is of interest to note that the amoebae, seldom if ever, are found attached to the under-surface of the dislodged agar films.

Syracuse watch glasses, containing about 8 cc distilled water, may be used instead of finger bowls. These dishes, with the bottom covered with agar, as described for the finger bowls, and with three grains of rice anchored in each, may be seeded with 15 to 25 amoebae from an old culture.

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SPECIAL ARTICLES

ON AN ALKALOID FROM ERGOT

DURING the past few months a new development in the chemistry and pharmacology of ergot has occurred through the almost simultaneous reports of the isolation of a new, apparently simpler and clinically more useful alkaloid from the fungus; the ergometrine of Dudley and Moir,[1] the ergotocin of Kharasch and Legault,[2] the alkaloid of Thompson,[3] and very recently the ergobasine of Stoll and Burckhardt.[4] Because of our own investigations of the structure of the ergot alkaloids, we have attempted to satisfy ourselves of the possible relationship of the new alkaloid or alkaloids to the lysergic acid group—ergotinine, ergotamine and ergoclavine—already studied by us.

The ergot powder residue which remained after it had been exhausted in the usual manner of its ether-soluble alkaloids was extracted with hot dilute acid (sulfuric or lactic acid). After neutralization of this extract with sodium carbonate and extraction with chloroform, a substance was obtained in very small yield which was characterized by its very sparing solubility in chloroform. It gave the usual color reactions of the ergot alkaloids. It was recrystallized by solution in methyl alcohol, addition of chloroform and concentration to remove the methyl alcohol. The same substance was obtained from fresh ergot powder by adhering to the exact directions as given by Dudley and Moir. Since the substance melted at 154°, it was assumed at first that we were dealing with the same alkaloid[5] described by Dudley and Moir and Kharasch and Legault. However, since further study of our material has given results which are not in agreement with the analytical results of these workers or with the rotation reported by the former, and since none of the substances of these workers was available to us for direct comparison, the question of identity must be left open for the present.

However, through the kindness of The Sandoz Company we have very recently received a small sample of the ergobasine (as the tartrate) of Stoll and Burckhardt. After isolation of the free base from this salt and crystallization from chloroform, it appeared to be identical with our own material. The former showed $[\alpha]_D^{25} = +32°$, and the latter $[\alpha]_D = +30°$ in methyl alcohol. The analytical results obtained with both samples were also in agreement. When crystallized from chloroform it separates with 1 mol of chloroform. $C_{19}H_{23}O_2N_3 \cdot CHCl_3$. Calculated C 53.98, H 5.44, Cl 23.93. Found C 54.54, H 5.83, Cl 22.83. Thus, these figures are in agreement with the formula presented by Stoll and Burckhardt, who recrystallized their alkaloid from alcohol. Because of the very limited supply of our own material, we have not employed this solvent.

Most important, however, has been the study of the hydrolysis of our alkaloid, which we had practically concluded before the publication of Stoll and Burckhardt. The results obtained appear definitely to substantiate the above formulation. On hydrolysis with 12.5 per cent. KOH in 50 per cent. alcohol, lysergic acid was obtained by our usual procedure and melted at 230°. Calculated: C 71.69, H 6.00. Found: C 71.49, H 5.60. No ammonia was produced during the hydrolysis, and no isobutyrylformic or pyruvic acids could be detected. After removal of most of the lysergic acid the material remaining in the mother liquor was subjected to hydrolysis with strong acid, a procedure heretofore employed by us where amino-acids were to be obtained and which also destroyed the residual lysergic acid. Instead, however, of an amino-acid a base resulted which was isolated as the sulfate. This salt proved to be the sulfate of an amino propanol $(C_3H_9ON)_2H_2SO_4$. Calculated: C 29.00, H 8.12. Found: C 29.25, H 8.05. This was substantiated by the preparation of a di-p-bromobenzoate which melted at 155°, $C_{17}H_{15}O_3NBr_2$. Calcu-

[1] H. W. Dudley and C. Moir, *Brit. Med. Jour.*, 1: 520, 1935.

[2] M. S. Kharasch and R. R. Legault, SCIENCE, 81: 388, 1935; *Jour. Am. Chem. Soc.*, 57: 956, 1140, 1935.

[3] M. R. Thompson, *Jour. Am. Pharm. Assoc.*, 24: 24, 185, 1935; SCIENCE, 81: 636.

[4] A. Stoll and E. Burckhardt, *Compt. rend.*, 200: 1680, 1935.

[5] The results of a preliminary study of our material which was perhaps erroneously considered by us to be ergometrine are soon appearing in the *Journal of Biological Chemistry*.

lated: C 46.26, H 3.43. Found: C 46.27, H 3.66. $[\alpha]_D^{28} = +48°$ (C = 0.125 in pyridine). The natural thought at once occurred that this base might have a biogenetic relationship to alanine. Hydroxyisopropylamine (2-aminopropanol-1) was prepared by reduction of l-alanine ester with sodium in butyl alcohol. The resulting base gave a di-p-bromobenzoate (C 45.97, H 3.75), which melted at 155° and showed no depression with the above derivative obtained from the alkaloid. However, $[\alpha]_D^{28} = -41°$ (C = 0.415 in pyridine). Therefore, the alkaloid amine is the natural form corresponding to d-alanine.

The alkaloid obtained by us (the ergobasine of Stoll and Burckhardt) is therefore the hydroxyisopropylamide of lysergic acid. In the formation of this substance, as in the case of the other ergot alkaloids studied by us, amino-acids or their derivatives are involved. It will be of interest to see what relationship to this alkaloid ergotocin will be shown to possess. Kharasch and Legault have given for it a formula $C_{21}H_{27}O_3N_3$, which thus differs from the former by C_2H_4O (or C_2H_5OH, alcohol?). The analyses of ergometrine reported by Dudley and Moir were made with the alkaloid recrystallized from benzene and could possibly have contained solvent.

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A SEROLOGICAL ESTIMATE OF THE ABSOLUTE CONCENTRATION OF TOBACCO MOSAIC VIRUS

ROBBINS[1] has assumed the molecular weight of tobacco mosaic virus to be in the neighborhood of 100,000, judging by the filtration studies of Duggar and Karrer, Waugh and Vinson, and MacClement and Smith. On the basis of infectivity tests on *Nicotiana glutinosa,* Caldwell[2] has estimated the concentration of infective particles to be of the order of 3×10^7 per cubic centimeter. If these two assumptions are correct, according to Robbins's calculations, the concentration of tobacco mosaic virus is such that 1 milligram is contained in 200,000 liters of expressed juice.

The most highly antigenic substance known, according to the serological literature, is the soluble specific carbohydrate of Pneumococcus, which gives a positive precipitin test with immune serum at about 1:2,500,000 (= .0004 milligrams per cubic centimeter). The most highly antigenic protein known is egg albumin, which gives a positive precipitin test at about 1:250,000 (= .004 milligrams per cubic centimeter). The writer has submitted evidence indicating that expressed saps of mosaic-diseased tobacco plants give precipitin titers of about 1:250,[3] and that it is the tobacco mosaic virus itself which is the antigen involved in this reaction.[4]

If tobacco mosaic virus sap is no more antigenic than the most highly antigenic substance known, the Pneumococcus carbohydrate, and if the minimal precipitating concentration of Pneumococcus carbohydrate is .0004 mg/cc, then it follows, *ipso facto,* that 1 cubic centimeter of tobacco mosaic expressed sap contains at least 0.1 milligram of virus (.0004 milligram × 250).

One might question the advisability of comparing the serological behavior of tobacco mosaic virus, which is entirely specific, with that of the Pneumococcus carbohydrate, which exhibits a striking lack of source-specificity. The serological behavior of egg albumin is more typically comparable with that of tobacco mosaic virus. Comparable precipitin tests of egg albumin and tobacco mosaic virus have been performed by the writer, and the results gave a precipitin titer of 1:250,000 for egg albumin. Comparing the precipitin titer of tobacco mosaic virus with that of egg albumin, one finds that if tobacco mosaic virus is no more antigenic than egg albumin, 1 cubic centimeter of virus sap would contain at least 1 milligram of virus antigen. From the serological results with tobacco mosaic virus and on the basis of the premises stated above, it is hence estimated that the concentration of virus in expressed virus sap is no less than 0.1–1.0 milligram per cubic centimeter.

Furthermore, it is known that crude tobacco mosaic sap when diluted to 1:1,000,000 gives approximately one necrotic lesion per leaf on *Nicotiana glutinosa,* and that about 0.1 cubic centimeter of sap dilution is used in making the inoculation. From these facts, and assuming that Robbins's hypothesis of a molecular weight of 100,000 is correct for tobacco mosaic virus, it would follow that a cubic centimeter of virus sap contains 6.06×10^{14} to 6.06×10^{15} molecules of virus, and that a single minimal infective dose on *N. glutinosa* corresponds to 60–600 million molecules of virus antigen. The enormous ratio of 60–600 million virus molecules to a single infection, if our premises are correct, may be due to (1) a great loss of opportunity to infect in the cases of the myriads of virus particles which fail to fall in a position suitable for infection, *i.e.,* on the naked protoplast exposed in the breaking of a leaf hair, and (2) a possible aggregation of particles such that many antigenic molecules may coalesce, thus greatly reducing the actual number of discrete infective units.

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[1] William J. Robbins, SCIENCE, 80: 275, 1934.
[2] John Caldwell, *Ann. Appl. Biol.,* 20: 100, 1933.
[3] Kenneth S. Chester, *Phytopath.* (in press).
[4] *Ibid.*

INFLUENCE OF DEUTERIUM OXIDE ON THE RATE OF PHOTOSYNTHESIS

A STUDY of the influence of heavy water on photosynthesis is of particular interest, not only on account of the fundamental importance of the process, but also because water enters directly into the chemical reaction. Recently we have measured the rate of photosynthesis when D_2O is used instead of H_2O.

The rate of O_2 evolution by Chlorella suspended in a carbonate-bicarbonate buffer was measured by means of Warburg manometers.[1] The illumination intensity was 2,000 meter candles, and the temperature was 25.7° C. The Chlorella was cultured in flasks by the usual method. For an experiment equal volumes of the culture were withdrawn and centrifuged, and the supernatant liquid was decanted. The cells were then washed several times by adding water, centrifuging and decanting. To one sample were added 5 cc of H_2O. To the other were added 5 cc of 100 per cent. D_2O (the resulting mixture being about 97 per cent. D_2O). Both were shaken and allowed to stand for 30 minutes. The water was then removed, after centrifuging, by decantation, and the buffer (as a rule Warburg's No. 9) was added to the moist cells. One buffer was made with H_2O and the other with 100 per cent. D_2O; due to water clinging to the cells, the latter buffer was diluted to about 99.9 per cent. Measurements were made within the first hour after the buffer had been added. Different cultures were used in the various experiments.

Table 1 gives the results. All the rates have been corrected for respiration except those in experiments 1 and 2. The correction, obtained experimentally, amounted to from 5 to 10 per cent. of the rate of photosynthesis.

TABLE 1

Exp.	Buffer	O_2 evolved in cmm/min./vessel	Ratio
1*	No. 9 H_2O	2.77	1.05
	No. 9 H_2O	2.63	
2	No. 9 D_2O	1.17	0.38
	No. 9 H_2O	3.10	
3	No. 9 D_2O	1.27	0.45
	No. 9 H_2O	2.84	
4	No. 9 H_2O	3.08	1.01
	No. 9 H_2O	3.05	
5	No. 7.5 D_2O	1.20	0.39
	No. 7.5 H_2O	3.04	
	No. 9 D_2O	1.30	0.42
	No. 9 H_2O	3.12	

* Exp. 1 indicates the precision of duplicate tests. There were approximately 120 million cells per vessel.

[1] O. Warburg, *Biochem. Zeit.*, 100: 230–270, 1919.

In experiment 3 the cells were allowed to remain for 16 hours in 97 per cent. D_2O before being transferred to the buffer; it may be seen that the rate of photosynthesis, relative to that for cells treated similarly with H_2O, is about the same as when the period of preliminary soaking was only 30 minutes. In experiment 4 the cells were soaked for 15 hours in 97 per cent. D_2O and, after removal of this, for 4 hours in ordinary water. The relative rates show that contact with D_2O for this period of time does not permanently injure the cells.

A comparison is made in experiment 5 of the rates obtained with buffer No. 9 and buffer No. 7.5 (the latter providing one third the CO_2 concentration of the former). The results show that a marked lowering of the CO_2 concentration causes only a slight decrease in the rate of photosynthesis. This indicates that the curves for rate of photosynthesis as a function of CO_2 concentration, for both H_2O and D_2O, are relatively flat in the range of CO_2 concentration employed. Therefore, the difference in the rates observed when using D_2O and H_2O buffers of the same molar concentration can hardly be due to differences in the CO_2 concentration in the two buffers.

Thus our experiments show that, when measured directly, the rate of photosynthesis with 99.9 per cent. D_2O is about 0.41 of that with ordinary H_2O. From chemical analyses of algae cultured in heavy water, Reitz and Bonhoeffer[2] estimated that the velocity constant for assimilation of D was about 0.43 that for assimilation of H.

The difference in rates of photosynthesis with D_2O and H_2O can not as yet be explained in terms of the mechanism of the reaction, but we are continuing our experiments with this object in view. The use of D_2O provides a new experimental approach to the problem of establishing a generally satisfactory theory for the mechanism of the photosynthetic process.

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[2] O. Reitz and K. F. Bonhoeffer, *Z. physik. Chem.*, A, 172: 369–388, 1935.

BOOKS RECEIVED

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